CLAIRE Real-time monitoring of healthy omega-3 production in micro-algae: A viability study

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Real-time monitoring of healthy omega-3 production in micro-algae

A viability study

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The Background

Eicosapentaenoic acid (EPA) is an omega 3 fatty-acid essential to humans, who mainly rely on fish oil as a source of EPA. Unfortunately, this is not a sustainable source

The Problem

Although algae is a much more sustainable and environmentally friendly source of EPA, there are limitations. Total lipid production can vary dramatically from batch to batch, from 20-50% of their total dry weight[1].

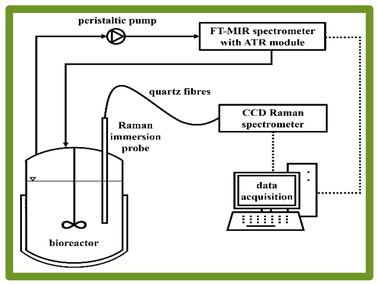
A Solution?

To aid in the production of fatty acids, and in particular EPA, a real time, in-vivo, online monitoring tool would be advantageous[2], to allow fast decision to be made to help boost the final yield of EPA.

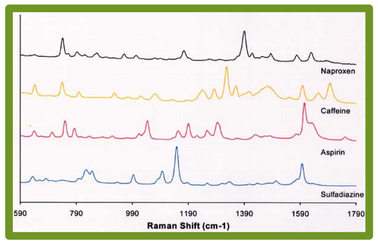
Potential Techniques

- Cell cytometry
- Differential Scanning Calorimetry
- Fourier Transform Infrared Spectroscopy
- Fluorescence Spectroscopy
- Mass Spectrometry
- Nuclear Magnetic Resonance
- Raman Spectroscopy

Technique	In-vivo	Non-destructive	Fast	Cost	Training
Cell Cytometry	✓			High	Extensive
Differential Scanning Calorimetry	✓			Moderate	Moderate
Fourier Transform Infrared Spectroscopy		✓	✓	High	Moderate
Fluorescence Spectroscopy	✓	✓	✓	Low	Basic
Mass Spectrometry				Low	Basic
Nuclear Magnetic Resonance	✓	✓		High	Moderate
Raman Spectroscopy	✓	✓	✓	Moderate	Basic



Measurement schematic used for yeast fermentation monitoring with Raman spectroscopy* (Schalk et al., 2019)[6]



An example of Raman Spectra (FBI, Public Domain)

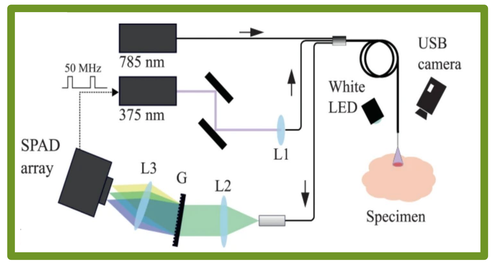
Raman Spectroscopy (RS)

Can provide information on cell structure, phase and much more. It is an extremely fast, non destructive technique that can be used on any phase. Only basic training is needed to use Raman spectroscopy. Although the cost for the equipment can be moderate, there is also a very small risk of sample heating with this procedure potentially leading to the destruction of the sample.

A Flow Cytometer (CC-BY-SA-3.0)

Cell Cytometry

Although it has already been successfully used for yeast and bacterial growth, it is very expensive and requires extensive training and on-going maintenance.



Fluorescence Spectrophotometer lifetime imagining layout* (Lagarto et al., 2020)[7]

Fluorescence Spectroscopy

A relatively easy procedure to perform that can measure the compounds in a solution. It is highly sensitive and so only very small samples are needed for measurement. It is also non- destructive and non-invasive. It is similar to FTIR-spectroscopy but much cheaper, although it has the same disadvantage in which not all molecules are fluorescent.

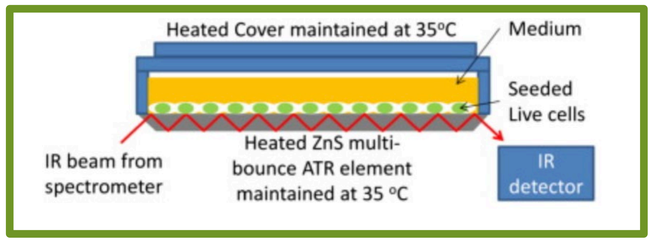
Differential Scanning Calorimeter and scanning results (Nick Birse, Wikimedia Commons)

Differential Scanning Calorimetry (DSC)

Can provide characteristic properties of a sample, however it is destructive and may struggle to analyse heterogeneous materials. There are also no real standards for DSC and so there has been difficulty in finding reproduceable results.

Conclusion

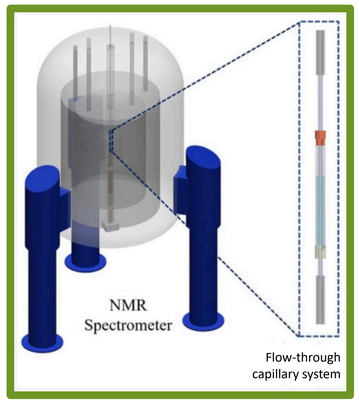
Although each of the techniques have advantages and disadvantages, the two most promising for the scope of this research are Raman spectroscopy and Fluorescence spectroscopy. There are already many case studies that have used these two techniques to study the make-up of algae cells in real time with promising results.



Schematic of of cell culture set up for live cells' FTIR measurement* (Fale et al., 2015)[3]

Fourier Transform Infrared Spectroscopy (FTIR)

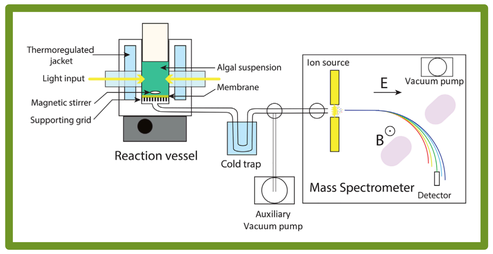
Relatively easy to perform procedure that determines the concentration of an analyte in a sample. Uses fluorescent properties of the sample, but not all compounds are fluorescent. Is also very expensive.



Nuclear Magnetic Resonance (NMR)

Can give detailed information about the structure of a chemical and biological compounds. Beside from being very expensive, a high-magnetic-field is needed which can affect electronic monitors and computer-controlled devices.

Conceptual diagram of a real-time NMR using flow-through capillary system* (Mehendale et al., 2020)[4]



Schematic of Membrane Inlet Mass Spectrometry* (Burlacot et al., 2020)[5]

Mass Spectrometry (MS)

Determines structural information of a sample, even from extremely small sample concentrations. On the down side, it can be quite expensive and time consuming.

Acknowledgements

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